

Docket: 43876-155



PATENT

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Application of : Customer Number: 20277  
HANSEN et al. : Confirmation Number: 4560  
Application No.: 10/757,516 : Group Art Unit: 2183  
Filed: January 15, 2004 : Examiner: Eric Coleman  
:

For: PROGRAMMABLE PROCESSOR AND SYSTEM FOR STORE MULTIPLEX OPERATION

**DECLARATION OF KORBIN VAN DYKE**

I, Korbin Van Dyke, state that:

**Personal Background**

1. I am an electrical/computer engineer with a BS and an MS in Electrical Engineering and Computer Science, and more than 20 years of industry and academic experience in computer architecture, processor microarchitecture, and logic design of complex VLSI systems, particularly microprocessors. I am a co-inventor on more than 50 issued U.S. patents, relating to a variety of subjects, including multiple ISA execution, hardware optimization for binary translation, video decoding ISA optimization, compatible ISA implementation techniques, speculative instruction execution, branch prediction, compatible segmentation and paging, standard PC sub-system virtualization, address generation, and logarithmic calculation.

2. I received a Master's of Science degree in Electrical Engineering and Computer Science (MS EECS) from the University of California (UC) Berkeley in 1982. Prior to receiving my Master's of Science degree, I received a Bachelor's of Science degree in Electrical Engineering and Computer Science from UC Berkeley in 1980.

3. While working toward my MS EECS degree, I also worked at UC Berkeley as a Research Assistant on the logic specification, logic verification, functional simulation, circuit design, and layout verification of an implementation of a Reduced Instruction Set Computer (RISC-I).

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4. After graduating from UC Berkeley, I worked at various engineering and management positions from 1982 until 2001 that included involvement in the specification, implementation, and debugging of complex computer architecture systems. Further selected details of my work during this period are set forth below in paragraphs 5 through 8.

5. From June 1982 to October 1987, I worked at VLSI Technology in San Jose, California as a VLSI Systems Engineer. I specified and designed a memory interface for a multi-mode display interface chip. I defined the instruction set architecture and microarchitecture of a programmable digital signal processor (DSP), and led a team that built and evaluated a microprocessor implementation of the DSP.

6. From October 1987 to May 1996, I worked at Nexgen Microsystems and remained with the company after it was acquired by Advanced Micro Devices (AMD) in January 1996, in various offices in San Jose and Milpitas, California. I designed the microarchitecture and logic details of the pipeline control for a superscalar, out-of-order, x86-compatible, multi-chip microprocessor, the Nx586. I also micro-architected and logic designed the branch prediction and multiple stream instruction fetch hardware of the Nx586. I oversaw various aspects of the physical design of the Nx586 (and its predecessors), including synthesis from Verilog code, place and route, timing closure, and layout versus schematic/netlist verification. I led a team that verified architectural correctness of the Nx586, and I led a team that debugged the Nx586 multi-chip silicon. I investigated several micro-architectural tradeoffs with respect to future high-performance x86 processors.

7. From May 1996 to May 2000, I worked at Chromatic Research and remained with the company after it was acquired by ATI Research Silicon Valley in November 1998, in Sunnyvale, and then Santa Clara, California. I oversaw the development and made personal contributions to the instruction set architecture of a dual-instruction-set processor (x86-compatible and RISC), including specifications for efficient transitions between the instruction sets, architectural hooks for efficient dynamic binary translation from the x86 instruction set to the RISC instruction set, and SIMD arithmetic and special hardware assists for media processing operations. I led a team that developed the pipeline control section of the processor (including Verilog coding and synthesis), and oversaw a team that developed the physical design of portions of the processor (place and route).

8. From June 2000 to December 2001, I worked as the Director of VLSI Development at XStream Logic and remained with the company as an Architect (after the company changed its name to Clearwater Networks in October 2001) in Los Gatos, California. As a VLSI Director, I led a team that was responsible for implementing a complex network processor from a set of specifications to silicon, using a simulatable high-level language description of the processor as a starting point. The team used a tool set that enabled automatic conversion of the high-level language into Verilog for simulation and synthesis, and then placement and routing. As an Architect, I defined and documented various architectural approaches for future network processors.

9. I am currently a sub-contractor of Patent Ventures, an intellectual property consulting company with offices in San Jose, California and Austin, Texas. I have been a sub-contractor for or employed by Patent Ventures as an intellectual property consultant since January

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2002 and became a registered U.S. Patent Agent (Reg. No. 52,313) in August 2002. I am also owner/operator of Van Dyke Consulting (formerly known as Korbin S Van Dyke Consulting), since May 2004, an intellectual property and technical services consulting company with an office in Sunol, California.

10. A copy of my CV is attached as Exhibit A.

### Summary of My Opinions

11. In preparation of this declaration I have reviewed U.S. Patent Application Serial No. 10/757,516. I have also reviewed U.S. Patent Nos. 6,295,599 and 5,742,840 (respectively the '599 and '840 patents) that the 10/757,516 patent application indirectly claims priority to, as well as appendices to the '599 and '840 patents (the Zeus and Terpsichore System Architecture manuals, respectively, and hereinafter referred to respectively as the Zeus and the Terpsichore manuals). I have reviewed the Office Action for the 10/757,516 patent application mailed on February 21, 2007, including the paragraphs on pages 6-7 that discuss the Response to Arguments and particularly the Examiner's conclusion that the priority for the claimed invention does not extend to the '599 or the '840 patents, since features of the claimed invention are not taught or supported by the '840 or '599 patents. My understanding is that the features of the claimed invention are taught and supported by complying with the written description requirement and the enablement requirement. My understanding of the written description requirement is that a patent disclosure must describe the claimed invention in sufficient detail that one of ordinary skill in the art can reasonably conclude that the inventor had possession of the claimed invention at the time of filing the patent disclosure. My understanding of the enablement requirement is that the patent disclosure must contain sufficient information regarding the subject matter of the claims to enable one of ordinary skill in the pertinent art to make and use the claimed invention. I further understand that whether the enablement requirement is met depends on whether undue experimentation is necessary for one of skill in the art to practice the invention in light of the patent disclosure.

12. Based on my review of the materials identified in paragraph 11, it is my opinion that:

(i) the disclosures of the '599 patent and the '840 patent each indicate that the inventors were in possession of the claimed (as amended) elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i)

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detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of the 10/757,516 patent application as of the August 24, 1999 filing date of the '599 patent and further as of the August 16, 1995 filing date of the '840 patent; and

(ii) the disclosures of the '599 patent and the '840 patent each would have enabled a person of ordinary skill in the art to make and use, without undue experimentation, the claimed (as amended) elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of the 10/757,516 patent application as of the August 24, 1999 filing date of the '599 patent and further as of the August 16, 1995 filing date of the '840 patent.

13. The disclosure of the '840 patent provides detailed information and description that I believe indicates that the inventors were in possession of the claimed (as amended) elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of the 10/757,516 patent application, and that I further believe would have enabled a person of ordinary skill in the art to make and use the claimed invention without undue experimentation. On at least pages 150-157 of the Terpsichore manual (describing Store and Store Immediate instructions, including Store Multiplex and Store Multiplex Immediate forms) there are detailed descriptions relating to the aforementioned claim elements.

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14. The disclosure of the '599 patent provides detailed information and description that I believe indicates that the inventors were in possession of the claimed (as amended) elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of the 10/757,516 patent application, and that I further believe would have enabled a person of ordinary skill in the art to make and use the claimed invention without undue experimentation. On at least pages 123-125 and 128-130 of the Zeus manual (describing Store and Store Immediate instructions, including Store Multiplex and Store Multiplex Immediate forms) there are detailed descriptions relating to the aforementioned claim elements.

15. A detailed explanation of the basis for my opinions is set forth in the remainder of this declaration.

### **Detailed Basis for My Opinions**

#### Level of Ordinary Skill in the Art:

16. Based on my review of the 10/757,516 patent application (referred to as the "media processor patent application"), I believe that the media processor patent application pertains to the technology of microprocessor design and microprocessor systems.

17. In my opinion a person of ordinary skill in the art of microprocessor design and microprocessor systems would possess a bachelor's degree in electrical engineering or computer science and have approximately five years of experience in the field of microprocessor design and microprocessor systems. Alternatively, an equivalent person could have had a master's degree in electrical engineering or computer science and have approximately two or more years of experience in the field of microprocessor design and microprocessor systems. This person would readily understand the conceptual design of a microprocessor and a microprocessor execution unit. The person of ordinary skill would have had access to a library of technical publications, periodicals, and textbooks.

Analysis of the disclosure of the '599 and '840 patent disclosures:

The disclosures of the '599 patent and the '840 patent each describe the claimed elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of the 10/757,516 patent application in sufficient detail that a person of ordinary skill in the art could reasonably conclude the inventors were in possession of the claimed invention, and that a person of ordinary skill in the art would have been enabled to make and use the claimed invention without undue experimentation as of the August 24, 1999 filing date of the '599 patent and further as of the August 16, 1995 filing date of the '840 patent:

18. Claim 1 (as amended) of the 10/757,516 patent application recites various elements:

- (a) an instruction path
- (b) a data path
- (c) an external interface operable to receive data from an external source and communicate the received data over the data path
- (d) a register file operable to receive and store data from the data path and communicate the stored data to the data path
- (e) an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to
- (f) decoding a single instruction for writing data to memory
- (g) based on a mask and data contained in at least one register
- (h) the mask comprising fields that each correspond to a field of the data contained in the at least one register
- (i) the execution unit is operable to:
- (j) detect some of the fields of the mask as having a predetermined value

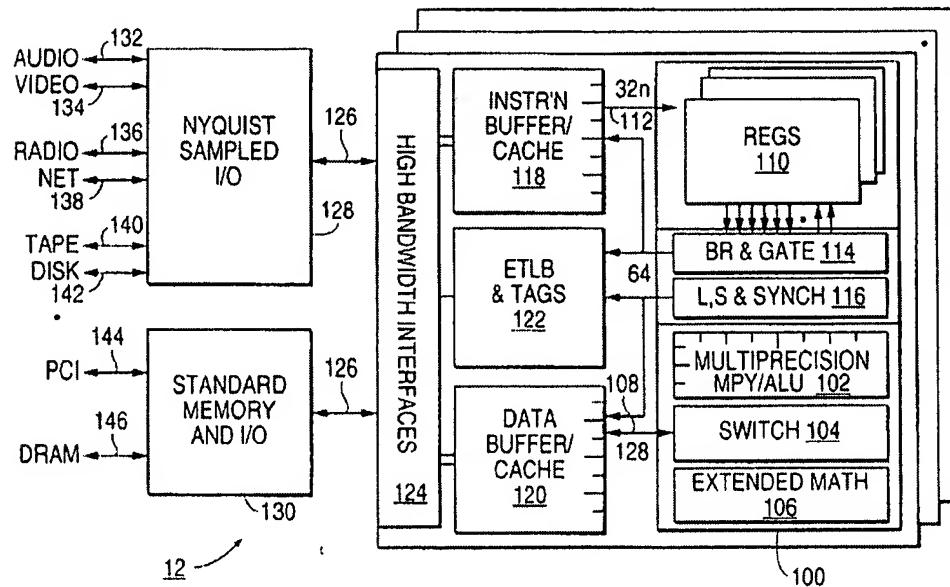
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- (k) to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and
- (l) cause the write-enabled data fields to be written to a specified memory location

19. For brevity, the following analysis focuses on and provides details relating to the '840 patent, while reciting summary information pointing out where similar descriptive information is provided in the '599 patent.

20. The '840 patent describes structure of a general purpose, programmable media processor. For example, Fig. 7 (reproduced below), illustrates an instruction path 112 that couples a combined instruction buffer/cache 118 to an execution unit 100 (see '840, column 16, lines 51-53). Fig. 7 also illustrates a data path 108 for transmitting media data streams (see '840, column 12, lines 3-7). Fig. 7 additionally illustrates high bandwidth interfaces 124 that communicate with external memory and input/output sources (see '840, column 18, lines 37-43); the high bandwidth interfaces 124 are in communication with the data path 108 via a data buffer/cache 120. Fig. 7 further illustrates the execution unit 100 (see '840, column 11, line 50 to column 12, line 15) having an ALU 102 that performs all logical and simple arithmetic operations (see '840, column 7, lines 8-11 and column 11, lines 50-60). Fig. 7 also illustrates a register file 110, to store and transmit data streams to and from the execution unit 100, that includes 64 general purpose registers (see '840, column 12, lines 56-64). Fig. 7 also illustrates a combined instruction buffer/cache 118 to store instructions (see '840, column 16, lines 51-67), and data buffer/cache 120 to store data received to and from the execution unit 100 and register file 110 (see '840, column 17, lines 1-14). Several pipeline organizations of the general purpose media processor are described (see '840 Fig. 11 and column 17, lines 15-52, as well as '840 Fig. 12 and column 17, lines 53-67). The '840 patent recites that an instruction set for the general purpose media processor is described by the Microfiche Appendix (see '840 column 13, lines 21-24). The Microfiche Appendix of the '840 patent is referred to herein as the Terpsichore manual. Similarly, the '599 patent describes structure of a general purpose, programmable processor for broadband applications (see, for example, Fig. 1 and associated descriptive text, such as column 4, line 30 to column 5, line 56). Additionally, the '599 patent includes and refers to a Microfiche Appendix that describes, for example, various pipeline organizations and an instruction set for a general purpose processor for broadband applications. The '599 patent Appendix is referred to herein as the Zeus manual.

FIG. 7



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21. The Terpsichore manual describes various elements of Claim 1, on at least pages 150-157 (attached as Exhibit B) with additional information on page 24 (attached as Exhibit C). Paragraphs 22-28 of this declaration discuss selected portions of those pages. Paragraphs 29-40 of this declaration describe how all of the elements of Claim 1 (as amended) are described at least by Fig. 7 and associated description of the '840 patent and Terpsichore manual pages 24 and 150-157. The '599 patent describes all of the elements of Claim 1 (as amended) at least by Fig. 1 and associated description, and the Zeus manual on at least pages 19-20, 123-125, and 128-130.

22. The Terpsichore manual describes several variations of Store Immediate instructions, including several Store Multiplex Immediate forms: "S.MUX.64.B.A.I" and "S.MUX.64.L.A.I", as described on page 154, and reproduced below (annotations added):

## Store Immediate

These operations add the contents of a register to a sign-extended immediate value to produce a virtual address, and store the contents of a register into memory.

### Operation codes

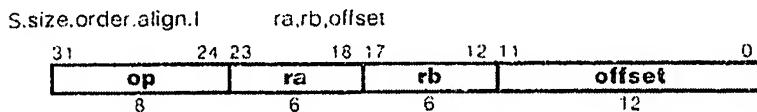
S.8.I47	Store byte immediate
S.16.B.A.I	Store double big-endian aligned immediate
S.16.B.I	Store double big-endian immediate
S.16.L.A.I	Store double little-endian aligned immediate
S.16.L.I	Store double little-endian immediate
S.32.B.A.I	Store quadlet big-endian aligned immediate
S.32.B.I	Store quadlet big-endian immediate
S.32.L.A.I	Store quadlet little-endian aligned immediate
S.32.L.I	Store quadlet little-endian immediate
S.64.B.A.I	Store octlet big-endian aligned immediate
S.64.B.I	Store octlet big-endian immediate
S.64.L.A.I	Store octlet little-endian aligned immediate
S.64.L.I	Store octlet little-endian immediate
S.128.B.A.I	Store hexlet big-endian aligned immediate
S.128.B.I	Store hexlet big-endian immediate
S.128.L.A.I	Store hexlet little-endian aligned immediate
S.128.L.I	Store hexlet little-endian immediate
S.AAS.64.B.A.I	Store add-and-swap octlet big-endian aligned immediate
S.AAS.64.L.A.I	Store add-and-swap octlet little-endian aligned immediate
S.CAS.64.B.A.I	Store compare-and-swap octlet big-endian aligned immediate
S.CAS.64.L.A.I	Store compare-and-swap octlet little-endian aligned immediate
S.MAS.64.B.A.I	Store multiplex-and-swap octlet big-endian aligned immediate
S.MAS.64.L.A.I	Store multiplex-and-swap octlet little-endian aligned immediate
S.MUX.64.B.A.I	Store multiplex octlet big-endian aligned immediate
S.MUX.64.L.A.I	Store multiplex octlet little-endian aligned immediate

One of ordinary skill in the art would readily understand that instances of instructions, including the foregoing Store Immediate instructions, are, under some circumstances, stored in combined instruction buffer/cache 118 of Fig. 7.

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23. The Terpsichore manual, on page 155, describes an instruction format for the Store Immediate instructions, reproduced below:

Format

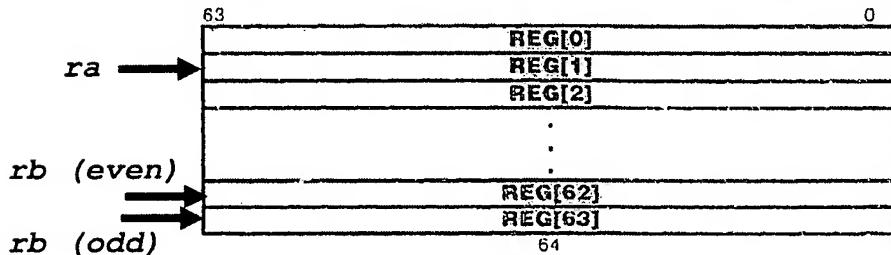


The operands of the Store Immediate instruction are 'ra', 'rb', and 'offset'. As described in more detail in paragraphs 24-27 of this declaration, a virtual address is formed by adding contents of a register specified by the 'ra' operand with a sign extension of the 'offset' operand. Memory at the virtual address is read. Contents of an even-numbered register specified by the 'rb' operand selectively controls multiplexing, bit-for-bit, between what was read at the virtual address from the memory and contents of an odd-numbered register also specified by the 'rb' operand. The multiplexing result is then written to the memory at the virtual address.

24. The Terpsichore manual, on page 24, describes the registers referenced as operands to instructions, and also describes associated definition code (hereinafter referred to as pseudo-code) that describes reading a single one of the registers and reading a pair of the registers, as reproduced below (with annotations illustrating examples for reading a single register specified by an 'ra' operand of '1' and a register pair specified by an 'rb' operand of '62'):

General Registers

Terpsichore user state includes 64 general registers. All are identical; there is no dedicated zero-valued register, and there are no dedicated floating-point registers.



Definition

```

def val ← RegRead(rn, size)
  case size of
    64:
      val ← REG[rn] ← read single
    128:
      if rn then
        raise ReservedInstruction
      endif
      val ← REG[rn+1] || REG[rn] ← read pair (even and odd)
  endcase
  enddef

```

The foregoing registers are included in register file 110 of Fig. 7 of the '840 patent.

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25. The Terpsichore manual, on pages 155-157, describes a definition of Store Immediate instructions, including several forms of Store Multiplex Immediate instructions, with pseudo-code. The pseudo-code begins with descriptions of decoding the Store Immediate instructions, reproduced below (with annotations highlighting description relevant to the Store Multiplex Immediate forms):

Definition

```

def StoreImmediate(op,ra,rb,offset) as
  case op of
    S8I,
    S16LI, S16LAI, S16BI, S16BAI,
    S32LI, S32LAI, S32BI, S32BAI,
    S64LI, S64LAI, S64BI, S64BAI,
    S128LI, S128LAI, S128BI, S128BAI
      function ← NONE
      SAAS64BAI, SAAS64LAI:
        function ← AAS
      SCAS64BAI, SCAS64LAI:
        function ← CAS
      SMAS64BAI, SMAS64LAI:
        function ← MAS
    → SMUX64BAI, SMUX64LAI:
      function ← MUX
  endcase
  case op of
    S6I:
      size ← B
      S16LI, S16LAI, S16BI, S16BAI:
        size ← 16
      S32LI, S32LAI, S32BI, S32BAI:
        size ← 32
    → S64LI, S64LAI, S64BI, S64BAI, SAAS64BAI, SAAS64LAI,
      SCAS64BAI, SCAS64LAI, SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
        size ← 64
      S128LI, S128LAI, S128BI, S128BAI:
        size ← 128
  endcase
  case op of
    S8I,
    S16LI, S16LAI, S16BI, S16BAI,
    S32LI, S32LAI, S32BI, S32BAI,
    S64LI, S64LAI, S64BI, S64BAI,
    SAAS64BAI, SAAS64LAI:
      rsize ← 64
    → SCAS64BAI, SCAS64LAI, SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
      rsize ← 128
      S128LI, S128LAI, S128BI, S128BAI:
        rsize ← 128
  endcase
  case op of
    S8I:
      align ← undefined
      S16LI, S32LI, S64LI, S128LI,
      S16BI, S32BI, S64BI, S128BI:
        align ← false
      S16LAI, S32LAI, S64LAI, S128LAI,
      S16BAI, S32BAI, S64BAI, S128BAI,
      SAAS64BAI, SAAS64LAI, SCAS64BAI, SCAS64LAI:
    → SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
      align ← true
  endcase
  case op of
    S8I:
      order ← undefined
      S16LI, S32LI, S64LI, S128LI,
      S16LAI, S32LAI, S64LAI, S128LAI,
    → SAAS64LAI, SCAS64LAI, SMAS64LAI, SMUX64LAI:
      order ← L
      S16BI, S32BI, S64BI, S128BI,
      S16BAI, S32BAI, S64BAI, S128BAI,
    → SAAS64BAI, SCAS64BAI, SMAS64BAI, SMUX64BAI:
      order ← B
  endcase

```

Thus, decoding of a Store Multiplex Immediate results in 'function' set to 'MUX', 'size' set to '64', 'rsize' set to '128', and 'align' set to 'true'.

26. The Terpsichore manual pseudo-code for the Store Immediate instructions continues with descriptions of the operation of the instructions based on the decoding, as reproduced below (with annotations highlighting description relevant to the Store Multiplex Immediate forms):

```

[1] → a ← RegRead(ra, 64)
[2] →   VirtAddr ← a + (offset11 50 ll offset)
[3] →   if align then
[4] →     if (VirtAddr and ((size/8)-1)) ≠ 0 then
[5] →       raise AccessDeniedByVirtualAddress
[6] →     endif
[7] →   endif
[8] →   m ← RegRead(rb, rsize)
[9] →   case function of
[10] →     NONE:
[11] →       StoreMemory(VirtAddr, size, order, msize-1..0)
[12] →     AAS:
[13] →       b ← LoadMemory(VirtAddr, size, order)
[14] →       StoreMemory(VirtAddr, size, order, m63..0+b)
[15] →       RegWrite(rb, 64, b)
[16] →     CAS:
[17] →       b ← LoadMemory(VirtAddr, size, order)
[18] →       if (b = m63..0) then
[19] →         StoreMemory(VirtAddr, size, order, m127..64)
[20] →       endif
[21] →       RegWrite(rb, 64, b)
[22] →     MAS:
[23] →       b ← LoadMemory(VirtAddr, size, order)
[24] →       n ← (m127..64 & m63..0) | (b & ~m63..0)
[25] →       StoreMemory(VirtAddr, size, order, n)
[26] →       RegWrite(rb, 64, b)
[27] →     MUX
[28] →       b ← LoadMemory(VirtAddr, size, order)
[29] →       n ← (m127..64 & m63..0) | (b & ~m63..0)
[30] →       StoreMemory(VirtAddr, size, order, n)
[31] →   endcase
[32] → enddec

```

Processing of a decoded Store Multiplex Immediate instruction begins by reading a 64-bit value from a register specified by the ‘*ra*’ operand into ‘*a*’ (see annotation [1]), for example reading REG[1] when ‘*ra*’ is 1. Processing continues by computing a virtual address as ‘*VirtAddr*’ set to the sum of ‘*a*’ and a sign extension of the ‘*offset*’ operand (see annotation [2]). Processing continues by reading a 128-bit value (‘*rsize*’ is ‘128’) from a pair of registers specified by the ‘*rb*’ operand into ‘*m*’ (see annotation [4]). The lower 64 bits of ‘*m*’ contain contents of the even-numbered register specified by ‘*rb*’, and the upper 64 bits of ‘*m*’ contain contents of the odd-numbered register specified by ‘*rb*’. For example, if ‘*rb*’ is 62, then REG[62] is read into the lower 64 bits of ‘*m*’ and REG[63] is read into the upper 64 bits of ‘*m*’. Processing continues at the ‘*MUX*’ label (see annotation [5]) (‘*function*’ is ‘*MUX*’), by reading a 64-bit value (‘*size*’ is ‘64’) from memory at an address specified by ‘*VirtAddr*’ into ‘*b*’. A store value is then computed as ‘*n*’ based on ‘*b*’, as well as the lower 64 bits of ‘*m*’ and the upper 64 bits of ‘*m*’. Processing then continues by writing the store value ‘*n*’ into the memory at the address specified by ‘*VirtAddr*’. One of ordinary skill in the art would readily understand that under some conditions, the reading from and the writing to memory would occur from and to data buffer/cache 120 of Fig. 7.

27. The store value is described as being computed as:

$$(m_{127..64} \& m_{63..0}) \mid b \& \sim m_{63..0})$$

where subscripts are understood to mean extraction of a bit field (thus  $m_{127..64}$  is the upper 64 bits of ' $m$ ', and  $m_{63..0}$  is the lower 64 bits of ' $m$ '), the ' $/$ ' operator is understood to be a bit-wise logical-OR, the ' $\&$ ' operator is understood to be a bit-wise logical-AND, and the ' $\sim$ ' is operator is understood to be a unary bit-wise logical-NOT. Since all elements of the store value computation are 64-bit values, each bit of the store value is computed according to:

$$H \ \& \ L \ / \ B \ \& \ \sim L$$

where ' $H$ ' is a respective bit of the upper 64 bits of ' $m$ ', ' $L$ ' is a respective bit of the lower 64 bits of ' $m$ ', and ' $B$ ' is a respective bit of ' $b$ '; i.e. a two-to-one multiplexer selecting between ' $H$ ' and ' $B$ ' via control input ' $L$ '. The store value computation is thus equivalent to a catenation of 64-bits of one-bit two-to-one multiplexers (hence the instruction is termed a Store Multiplex Immediate instruction), each multiplexer having a respective bit of the lower 64 bits of ' $m$ ' as a control input, and a respective bit of the upper 64 bits of ' $m$ ' as a first data input and a respective bit of ' $b$ ' as a second data input. The first data input (a respective bit of the upper portion of ' $m$ ') is selected when the control input is a logic one, and the second data input (a respective bit of ' $b$ ') is selected when the control input is a logic zero. One of ordinary skill in the art would readily understand that the computation of the store value would occur in ALU 102 of Fig. 7.

28. Thus the Store Multiplex Immediate instructions are described as forming a virtual address by adding contents of a register specified by a first operand to a sign-extended offset supplied as an immediate operand, reading a value from memory at the virtual address, multiplexing bit-for-bit the value with contents of an odd-numbered register specified by a second operand via a multiplexing control from contents of an even-numbered register specified by the second operand, and writing a result of the multiplexing to the memory at the virtual address.

29. Disclosure provided by the '840 patent, at least by Fig. 7 and associated descriptive text, and Terpsichore manual pages 24 and 150-157, describe all elements of Claim 1 (as amended), as described in more detail in paragraphs 29-40 of this declaration.

30. The element an instruction path is described at least by the '840 patent Fig. 7 and at column 16, lines 51-53.

31. The element a data path is described at least by the '840 patent Fig. 7 and at column 12, lines 3-7.

32. The element an external interface operable to receive data from an external source and communicate the received data over the data path is described at least by the '840 patent Fig. 7 and at column 18, lines 37-43.

33. The element a register file operable to receive and store data from the data path and communicate the stored data to the data path is described at least by the '840 patent Fig. 7 and at column 12, lines 56-64.

34. The element an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in

response to is described at least by the '840 patent Fig. 7 and at column 11, line 50 to column 12, line 15; and column 16, lines 51-53.

35. The element decoding a single instruction for writing data to memory is described by the Terpsichore manual, as annotated and summarized by paragraphs 22-25 of this declaration. The Store Multiplex Immediate instructions are clearly each single instructions, as evidenced at least by the dedicated operation codes "S.MUX.64.B.A.I" and "S.MUX.64.L.A.I", and are clearly for writing data to memory, as they are store instructions.

36. The element based on a mask and data contained in at least one register is described by the Terpsichore manual, as annotated and summarized by paragraphs 26-27 of this declaration. The store value is dependent on the lower 64 bits of ' $m$ ' (from a register specified by an operand of the Store Multiplex Immediate instruction) that correspond to a mask, as each respective bit, when a logic one, masks off a corresponding bit of ' $b$ '. The store value is further dependent on the ' $b$ ' value (from another register specified by the operand of the Store Multiplex Immediate instruction) that corresponds to data, as each respective bit replaces, when a corresponding control bit is a logic one, a corresponding bit read from memory.

37. The element the mask comprising fields that each correspond to a field of the data contained in the at least one register is described by the Terpsichore manual, as annotated and summarized by paragraphs 26-27 of this declaration. The bit-wise computation of the store value uses each of the lower 64 bits of ' $m$ ' to select, bit-for-bit, between two 64-bit values (the upper 64 bits of ' $m$ ' and the 64 bits of the ' $b$ ' value). Thus each bit of the lower 64 bits of ' $m$ ' comprises a mask field and each bit of ' $b$ ' is a corresponding data field.

38. The element detect some of the fields of the mask as having a predetermined value is described by the Terpsichore manual, as annotated and summarized by paragraphs 26-27 of this declaration. The bit-wise computation of the store value effectively selects for writing corresponding bits based on respective control input bits that are a logic one (i.e. a predetermined value).

39. The element to identify corresponding fields of the data contained in the at least one register as write-enabled data fields is described by the Terpsichore manual, as annotated and summarized by paragraphs 26-27 of this declaration. Each of the corresponding bits selected for writing are write-enabled data fields, in contrast with the corresponding bits not selected for writing that remain unchanged, and thus are not write-enabled data fields.

40. The element cause the write-enabled data fields to be written to a specified memory location is described by the Terpsichore manual, as annotated and summarized by paragraphs 26-27 of this declaration. The store value is written to the virtual address that is a specified memory location.

41. Thus every element of Claim 1 (as amended) is described by the '840 patent, at least by Fig. 7 and associated descriptive text, and the Terpsichore manual on pages 24 and 150-157. In addition, every element of Claim 1 (as amended) is also described by the '599 patent, at least by Fig. 1 and associated descriptive text, and the Zeus manual on pages 19-20 (describing general registers), pages 123-125 (pseudo-code for Store instructions, including Store Multiplex

instructions), and pages 128-130 (pseudo-code for Store Immediate instructions, including Store Multiplex Immediate Instructions).

42. Based on the above, I believe that a person of ordinary skill in the art would readily conclude that the disclosures of the '599 patent and the '840 patent each describe elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location", as recited in claim 1 (as amended) of the 10/757,516 patent application, in sufficient detail to conclude that the inventors had possession of the claimed invention, as of the August 24, 1999 filing date of the '599 patent and further as of the August 16, 1995 filing date of the '840 patent, and that the disclosures of the '599 patent and the '840 patent each provide sufficient detail to enable a person of ordinary skill in the art to make and use the claimed invention (as amended) of the 10/757,516 patent application without undue experimentation as of the August 24, 1999 filing date of the '599 patent and further as of the August 16, 1995 filing date of the '840 patent.

Summary and Closing:

43. The '599 patent, including the Zeus manual, provides sufficient information in sufficient detail describing the claimed invention (as amended) of the 10/757,516 patent application, that one of ordinary skill in the art would reasonably conclude that the inventors had possession of the claimed invention at the time of filing the '599 patent. Further, the '599 patent, including the Zeus manual, provides sufficient information regarding the subject matter of the claimed invention (as amended) of the 10/757,516 patent application to enable one of ordinary skill in the pertinent art to make and use the claimed invention without undue experimentation. In addition, the '840 patent, including the Terpsichore manual, provides sufficient information in sufficient detail describing the claimed invention (as amended) of the 10/757,516 patent application, that one of ordinary skill in the art would reasonably conclude that the inventors had possession of the claimed invention at the time of filing the '840 patent. Further, the '840 patent, including the Terpsichore manual, provides sufficient information regarding the subject matter of the claimed invention (as amended) of the 10/757,516 patent application to enable one of ordinary skill in the pertinent art to make and use the claimed invention without undue experimentation. Therefore, I believe that each of the '599 patent, including the Zeus manual, and the '840 patent, including the Terpsichore manual, provide adequate written description and enablement as required by 35 USC § 112 for the elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the

Declaration of Korbin S Van Dyke

instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" of claim 1 (as amended) of the 10/757,516 patent application.

44. I have had no communication with any of the inventors of the 10/757,516 patent application (Craig Hansen and John Moussouris) relating to any material in this declaration.

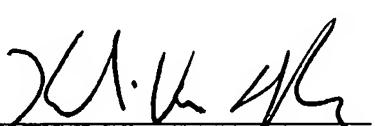
45. I have been hired as a consultant in connection with procedures before the United States Patent and Trademark Office (USPTO) regarding patents and patent applications assigned to Microunity Systems Engineering, Inc., including the media processor patent application. I am being compensated for my services at the rate of \$325/hour. Other than acting as a consultant in connection with procedures before the USPTO, I have no interest or connection with Microunity Systems Engineering, Inc.

46. During my evaluation of the media processor patent application, I have been impressed by the thoroughness and overall high-quality of the Zeus and Terpsichore manuals. The manuals provide clear and unambiguous descriptions of media processing systems and are thorough and well-written. The manuals provide comprehensive descriptions of instructions in complete architectural detail. The information in the manuals would have been readily understood and easily accessible to software engineers coding the media processing systems, and hardware engineers implementing microprocessors for use in the media processing systems, and that is exactly what architecture reference manuals should be. This is not surprising, since the '599 patent and '840 patent each include an architecture manual that is intended to enable hardware engineers to do exactly that – design, build, and implement a media processor that would include circuitry for elements of "an instruction path", "a data path", "an external interface operable to receive data from an external source and communicate the received data over the data path", "a register file operable to receive and store data from the data path and communicate the stored data to the data path", and "an execution unit coupled to the instruction and data paths and operable to decode and execute instructions received from the instruction path, wherein in response to decoding a single instruction for writing data to memory based on a mask and data contained in at least one register, the mask comprising fields that each correspond to a field of the data contained in the at least one register, the execution unit is operable to: (i) detect some of the fields of the mask as having a predetermined value to identify corresponding fields of the data contained in the at least one register as write-enabled data fields; and (ii) cause the write-enabled data fields to be written to a specified memory location" as described in the Zeus and the Terpsichore architecture manuals.

Declaration of Korbin S Van Dyke

47. I hereby declare that all statements made herein are of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing therefrom.

Date: 8/15/2007

Korbin Van Dyke: 

Address: 3343 Little Valley Rd.  
Sunol, CA 94586



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### **Personal Statement**

I am an expert in Microprocessor Logic Design, VLSI Systems, and related intellectual property. Throughout more than twenty years of involvement in the specification, implementation, and debugging of complex computer architecture systems, I've enjoyed the daily challenge of learning, focusing on details, and providing working systems to end customers. In August, 2002, I became a registered US patent agent and intellectual property consultant. I now enjoy aiding clients and their counsel in understanding these technologies, and protecting their intellectual property investments in these areas.

### **Experience Summary**

- 04/2004-present
  - Owner/Operator, Korbin S Van Dyke Consulting, office in Sunol, California

I am assisting clients in understanding technical aspects of complex intellectual property issues with emphasis on complex digital systems corresponding to my technical expertise. I have acted on behalf of plaintiffs and defendants in various intellectual property licensing and litigation projects.

Acting as a technical expert on a successful licensing project, I analyzed a collection of more than 100 computer microarchitecture patents and related prior art. I identified potentially infringing products based on publicly available information, and produced a collection of associated claim charts. In addition, I assisted the client in drafting further claims targeting other potentially infringing products.

- 01/2002-present
  - Senior Member Technical Staff and Sub-Contractor, PatentVentures, offices in California and Texas

I am authoring complex patent applications, analyzing existing intellectual property, and expanding the scope of client patent coverage. These contributions are in the areas of complex VLSI system design, leveraging my technical expertise relevant to these systems.

- 10/2001-12/2001
  - Architect, Clearwater Networks (previously XStream Logic), Los Gatos, CA

## Declaration of Korbin S Van Dyke -- Exhibit A

I was the senior technical contributor in the architecture group. I was responsible for defining, documenting, and championing the architecture of future network processor products.

- 06/2000-09/2001
  - Director, VLSI Development, XStream Logic, Los Gatos, CA

I was responsible for building and leading the VLSI team developing a complex network processor. I owned the overall chip implementation and debug schedule, resource management decisions, and was also the senior technical contributor. The scope of work included front end design, verification, back end design, and debug. I built the team from ten to 35 members, and increased the skill set from front end logic design and EDA to include circuit, micro-architecture, and verification. In addition, I lead a “virtual ops” group until the operations team came on board.

- 06/1999-05/2000
  - Senior Manager, Architecture, ATI Research Silicon Valley, Santa Clara, CA

Previous positions (at ATI):

- Manager, ATI Research Silicon Valley, Santa Clara, CA

I was responsible for the top-level CPU architectural definition and partitioning, working directly with a technical writer to specify the architecture unambiguously. This requires a micro-code programmer’s model negotiated between the micro-code and hardware micro-architecture implementers and logic designers. I lead the micro-code development and performance analysis teams. I also directly managed the place and route group.

I was responsible for leading a cross-functional team to design in complete X86 compatibility. This requires investigations into ambiguous or complex cases, specifying the architecture of the solution (hardware and/or software), and coordinating the complex hardware/software solutions.

I worked with contributors across the CPU to encourage and facilitate filing patent applications covering the inventions at architectural and implementation levels.

I led a small team designing the pipeline control section of a super-scalar in-order x86 compatible processor. The team was responsible for unit definition and micro-architecture, block partitioning, RTL coding, synthesis, custom macro-specification, timing analysis and improvement, cell placement, and cell routing. The team was charged with meeting area, timing, and bug count goals. I coordinated the activities of the group and negotiated interfaces with the other three units of the processor: memory, instruction fetch/conversion, and datapaths, in addition to providing specific technical guidance and solving problems.

- 05/1996-5/1999
  - Member Technical Staff, Architect, Chromatic Research, Sunnyvale, CA (merged with ATI Technology Nov 1998)

## Declaration of Korbin S Van Dyke -- Exhibit A

I drove closure of the final details of the programmer's model of a complex instruction set architecture device with multiple processors. Each processor is super-scalar (in order), dual instruction set capable (industry standard X86 plus proprietary native), with hardware optimizations to support binary translation and media operations (MPEG decoding and encoding, decryption, and 3D lighting and geometry calculations).

I was a key contributor to the team refining the product definition, system and CPU level partitioning, CPU ISA, and internal CPU micro-architecture. I personally connected logic and circuit designers with media programmers via negotiation and analysis to enable a high performance well thought out and cost effective total solution.

I examined external intellectual property to identify exposures and workarounds. I contributed directly to the creation of internal intellectual property: multiple ISA execution, hardware optimization for binary translation, video decoding ISA optimization, X86 compatible ISA implementation techniques, standard PC sub-system virtualization mechanisms, and compatible segmentation and paging methods.

- 10/1987-05/1996
  - Senior Manager, AMD (formerly Nexgen), Milpitas, CA

Previous positions (at Nexgen):

- Director Processor Development
- Project manger Architecture Development
- Senior Member Technical Staff
- Member Technical Staff

I investigated possible micro-architectures for the eighth generation x86 ISA implementation, including: overall CPU performance (using an in-house performance simulation tool), expected cycle time (based on logic design of critical paths), and required process technology.

I was a key contributor toward the first Nexgen product (Nx586) – a super-scalar, out of order, fifth generation implementation of the x86 ISA. This product briefly shipped to customers.

My individual contributions included: pipeline control logic design, branch prediction and multiple stream instruction fetch micro-architecture and logic design, lab debug, timing bug identification and resolution, performance analysis and improvement, and overall design correctness.

Management responsibilities included: architectural verification, lab debug, and eventually the entire implementation of the CPU in groups from 4 to 20 people.

- 6/1982-10/1987
  - VLSI Systems Engineer, VLSI Technology, San Jose, CA

I led a small team as an active manager in the design, implementation, and prototype evaluation of a programmable digital signal processor. The project began with the definition of the

## Declaration of Korbin S Van Dyke -- Exhibit A

instruction set architecture, and culminated in a working modem demonstration constructed from the first silicon.

I specified and designed the memory interface for a multi-mode display interface chip (first silicon was used for product demonstration), reverse engineered a small CMOS standard part chip, and supported a telecommunications chip set customer design project.

- 6/1981-6/1982
  - Research Assistant, UC Berkeley, Berkeley, CA

I assisted in the NMOS logic specification, logic verification, functional simulation, circuit design, and layout verification of an implementation of a Reduced Instruction Set Computer (RISC-I).

### **Education**

6/1982 MS, EECS      UC Berkeley, Berkeley, CA    GPA: 4.0/4.0

6/1980 BS, EECS      UC Berkeley, Berkeley, CA    GPA: 3.9/4.0

### **Activities**

I have been inducted into: Phi Beta Kappa, Tau Beta Pi , and Eta Kappa Nu

I am a member of IEEE (since 1978)

I am a member of ACM (since 1983)

### **Patents**

I am a co-inventor on more than 50 patents. These patents relate to a variety of subjects, including: multiple ISA execution, hardware optimization for binary translation, video decoding ISA optimization, compatible ISA implementation techniques, speculative instruction execution, branch prediction, compatible segmentation and paging, standard PC sub-system virtualization, address generation, and logarithmic calculation.

Terpsichore System Architecture

Wed, Aug 2, 1995

Store

These operations add the contents of two registers to produce a virtual address, and store the contents of a register into memory.

Operation codes

S.8 <sup>46</sup>	Store byte
S.16.B	Store double big-endian
S.16.B.A	Store double big-endian aligned
S.16.L	Store double little-endian
S.16.L.A	Store double little-endian aligned
S.32.B	Store quadlet big-endian
S.32.B.A	Store quadlet big-endian aligned
S.32.L	Store quadlet little-endian
S.32.L.A	Store quadlet little-endian aligned
S.64.B	Store octlet big-endian
S.64.B.A	Store octlet big-endian aligned
S.64.L	Store octlet little-endian
S.64.L.A	Store octlet little-endian aligned
S.128.B	Store hexlet big-endian
S.128.B.A	Store hexlet big-endian aligned
S.128.L	Store hexlet little-endian
S.128.L.A	Store hexlet little-endian aligned
S.AAS.64.B.A	Store add-and-swap octlet big-endian aligned
S.AAS.64.L.A	Store add-and-swap octlet little-endian aligned
S.CAS.64.B.A	Store compare-and-swap octlet big-endian aligned
S.CAS.64.L.A	Store compare-and-swap octlet little-endian aligned
S.MAS.64.B.A	Store multiplex-and-swap octlet big-endian aligned
S.MAS.64.L.A	Store multiplex-and-swap octlet little-endian aligned
S.MUX.64.B.A	Store multiplex octlet big-endian aligned
S.MUX.64.L.A	Store multiplex octlet little-endian aligned

size	ordering				alignment
8					
16	32	64	128	L	B
16	32	64	128	L	B

<sup>46</sup>S.8 need not specify byte ordering, nor need it specify alignment checking, as it stores a single byte.

Terpsichore System Architecture

Wed, Aug 2, 1995

Format

op ra,rb,rc

31	24 23	18 17	12 11	6 5	0
	<b>S.MINOR</b>	<b>ra</b>	<b>rb</b>	<b>rc</b>	<b>op</b>

8

6

6

6

6

Description

A virtual address is computed from the sum of the contents of register ra and register rb. The contents of register rc, treated as the size specified, is stored in memory using the specified byte order.

If alignment is specified, the computed virtual address must be aligned, that is, it must be an exact multiple of the size expressed in bytes. If the address is not aligned an "access disallowed by virtual address" exception occurs.

Definition

```
def Store(op,ra,rb,rc) as
  case op of
    S8,
    S16L, S16LA, S16B, S16BA,
    S32L, S32LA, S32B, S32BA,
    S64L, S64LA, S64B, S64BA,
    S128L, S128LA, S128B, S128BA:
      function ← NONE
    SAAS64BA, SAAS64LA:
      function ← AAS
    SCAS64BA, SCAS64LA:
      function ← CAS
    SMAS64BA, SMAS64LA:
      function ← MAS
    SMUX64BA, SMUX64LA:
      function ← MUX
  endcase
  case op of
    S8:
      size ← 8
    S16L, S16LA, S16B, S16BA:
      size ← 16
    S32L, S32LA, S32B, S32BA:
      size ← 32
    S64L, S64LA, S64B, S64BA,
    SAAS64BA, SAAS64LA:
      size ← 64
    SCAS64BA, SCAS64LA, SMAS64BA, SMAS64LA, SMUX64BA, SMUX64LA:
      size ← 64
    S128L, S128LA, S128B, S128BA:
      size ← 128
  endcase
  case op of
    S8,
    S16L, S16LA, S16B, S16BA,
    S32L, S32LA, S32B, S32BA,
```

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```

S64L, S64LA, S64B, S64BA,
SAAS64BA, SAAS64LA:
    rsize ← 64
SCAS64BA, SCAS64LA SMAS64BA, SMAS64LA, SMUX64BA, SMUX64LA:
    rsize ← 128
S128L, S128LA, S128B, S128BA:
    rsize ← 128
endcase
case op of
    S8:
        align ← undefined
        S16L, S32L, S64L, S128L,
        S16B, S32B, S64B, S128B:
            align ← false
        S16LA, S32LA, S64LA, S128LA,
        S16BA, S32BA, S64BA, S128BA,
        SAAS64BA, SAAS64LA, SCAS64BA, SCAS64LA,
        SMAS64BA, SMAS64LA, SMUX64BA, SMUX64LA:
            align ← true
    endcase
    case op of
        S8:
            order ← undefined
            S16L, S32L, S64L, S128L,
            S16LA, S32LA, S64LA, S128LA,
            SAAS64LA, SCAS64LA, SMAS64LA, SMUX64LA:
                order ← L
            S16B, S32B, S64B, S128B,
            S16BA, S32BA, S64BA, S128BA,
            SAAS64BA, SCAS64BA, SMAS64BA, SMUX64BA:
                order ← B
    endcase
    a ← RegRead(ra, 64)
    b ← RegRead(rb, 64)
    VirtAddr ← a + b
    if align then
        if (VirtAddr and ((size/8)-1)) ≠ 0 then
            raise AccessDeniedByVirtualAddress
        endif
    endif
    m ← RegRead(rc, rsize)
    case function of
        NONE:
            StoreMemory(VirtAddr, size, order, msize-1..0)
        AAS:
            c ← LoadMemory(VirtAddr, size, order)
            StoreMemory(VirtAddr, size, order, m63..0+c)
            RegWrite(rc, 64, c)
        CAS:
            c ← LoadMemory(VirtAddr, size, order)
            if (c = m63..0) then
                StoreMemory(VirtAddr, size, order, m127..64)
            endif
            RegWrite(rc, 64, c)
        MAS:
            c ← LoadMemory(VirtAddr, size, order)
            n ← (m127..64 & m63..0) | (c & ~m63..0)
            StoreMemory(VirtAddr, size, order, n)

```

Terpsichore System Architecture

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```
RegWrite(rc, 64, c)
MUX:
  c ← LoadMemory(VirtAddr, size, order)
  n ← (m127..64 & m63..0) | (c & ~m63..0)
  StoreMemory(VirtAddr, size, order, n)
endcase
enddef
```

#### Exceptions

Reserved instruction  
Access disallowed by virtual address  
Access disallowed by tag  
Access disallowed by global TLB  
Access disallowed by local TLB  
Access detail required by tag  
Access detail required by local TLB  
Access detail required by global TLB  
Cache coherence intervention required by tag  
Cache coherence intervention required by local TLB  
Cache coherence intervention required by global TLB  
Local TLB miss  
Global TLB miss



Terpsichore System Architecture

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Store Immediate

These operations add the contents of a register to a sign-extended immediate value to produce a virtual address, and store the contents of a register into memory.

Operation codes

S.8.I <sup>47</sup>	Store byte immediate
S.16.B.A.I	Store double big-endian aligned immediate
S.16.B.I	Store double big-endian immediate
S.16.L.A.I	Store double little-endian aligned immediate
S.16.L.I	Store double little-endian immediate
S.32.B.A.I	Store quadlet big-endian aligned immediate
S.32.B.I	Store quadlet big-endian immediate
S.32.L.A.I	Store quadlet little-endian aligned immediate
S.32.L.I	Store quadlet little-endian immediate
S.64.B.A.I	Store octlet big-endian aligned immediate
S.64.B.I	Store octlet big-endian immediate
S.64.L.A.I	Store octlet little-endian aligned immediate
S.64.L.I	Store octlet little-endian immediate
S.128.B.A.I	Store hexlet big-endian aligned immediate
S.128.B.I	Store hexlet big-endian immediate
S.128.L.A.I	Store hexlet little-endian aligned immediate
S.128.L.I	Store hexlet little-endian immediate
S.AAS.64.B.A.I	Store add-and-swap octlet big-endian aligned immediate
S.AAS.64.L.A.I	Store add-and-swap octlet little-endian aligned immediate
S.CAS.64.B.A.I	Store compare-and-swap octlet big-endian aligned immediate
S.CAS.64.L.A.I	Store compare-and-swap octlet little-endian aligned immediate
S.MAS.64.B.A.I	Store multiplex-and-swap octlet big-endian aligned immediate
S.MAS.64.L.A.I	Store multiplex-and-swap octlet little-endian aligned immediate
S.MUX.64.B.A.I	Store multiplex octlet big-endian aligned immediate
S.MUX.64.L.A.I	Store multiplex octlet little-endian aligned immediate

size	ordering				alignment
8					
16	32	64	128	L	B
16	32	64	128	L	B

<sup>47</sup>S.8.I need not specify byte ordering, nor need it specify alignment checking, as it stores a single byte.

Terpsichore System Architecture

Wed, Aug 2, 1995

Format

S.size.order.align.l ra,rb,offset

31	24 23	18 17	12 11	0
	<b>op</b>	<b>ra</b>	<b>rb</b>	<b>offset</b>
8	6	6	12	

Description

A virtual address is computed from the sum of the contents of register **ra** and the sign-extended value of the **offset** field. The contents of register **rb**, treated as the size specified, is stored in memory using the specified byte order.

If alignment is specified, the computed virtual address must be aligned, that is, it must be an exact multiple of the size expressed in bytes. If the address is not aligned an "access disallowed by virtual address" exception occurs.

Definition

```
det StoreImmediate(op,ra,rb,offset) as
  case op of
    S8I,
    S16LI, S16LAI, S16BI, S16BAI,
    S32LI, S32LAI, S32BI, S32BAI,
    S64LI, S64LAI, S64BI, S64BAI,
    S128LI, S128LAI, S128BI, S128BAI:
      function ← NONE
    SAAS64BAI, SAAS64LAI:
      function ← AAS
    SCAS64BAI, SCAS64LAI:
      function ← CAS
    SMAS64BAI, SMAS64LAI:
      function ← MAS
    SMUX64BAI, SMUX64LAI:
      function ← MUX
  endcase
  case op of
    S8I:
      size ← 8
    S16LI, S16LAI, S16BI, S16BAI:
      size ← 16
    S32LI, S32LAI, S32BI, S32BAI:
      size ← 32
    S64LI, S64LAI, S64BI, S64BAI, SAAS64BAI, SAAS64LAI,
    SCAS64BAI, SCAS64LAI, SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
      size ← 64
    S128LI, S128LAI, S128BI, S128BAI:
      size ← 128
  endcase
  case op of
    S8I,
    S16LI, S16LAI, S16BI, S16BAI,
    S32LI, S32LAI, S32BI, S32BAI,
    S64LI, S64LAI, S64BI, S64BAI,
    SAAS64BAI, SAAS64LAI:
```

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```

rsize ← 64
SCAS64BAI, SCAS64LAI, SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
rsize ← 128
S128LI, S128LAI, S128BI, S128BAI:
rsize ← 128
endcase
case op of
S8I:
    align ← undefined
    S16LI, S32LI, S64LI, S128LI,
    S16BI, S32BI, S64BI, S128BI:
    align ← false
    S16LAI, S32LAI, S64LAI, S128LAI,
    S16BAI, S32BAI, S64BAI, S128BAI,
    SAAS64BAI, SAAS64LAI, SCAS64BAI, SCAS64LAI,
    SMAS64BAI, SMAS64LAI, SMUX64BAI, SMUX64LAI:
    align ← true
endcase
case op of
S8I:
    order ← undefined
    S16LI, S32LI, S64LI, S128LI,
    S16LAI, S32LAI, S64LAI, S128LAI,
    SAAS64LAI, SCAS64LAI, SMAS64LAI, SMUX64LAI:
    order ← L
    S16BI, S32BI, S64BI, S128BI,
    S16BAI, S32BAI, S64BAI, S128BAI,
    SAAS64BAI, SCAS64BAI, SMAS64BAI, SMUX64BAI:
    order ← B
endcase
a ← RegRead(ra, 64)
VirtAddr ← a + (offset1150 || offset)
if align then
    if (VirtAddr and ((size/8)-1)) ≠ 0 then
        raise AccessDisallowedByVirtualAddress
    endif
endif
m ← RegRead(rb, rsize)
case function of
NONE:
    StoreMemory(VirtAddr, size, order, msize-1..0)
AAS:
    b ← LoadMemory(VirtAddr, size, order)
    StoreMemory(VirtAddr, size, order, m63..0+b)
    RegWrite(rb, 64, b)
CAS:
    b ← LoadMemory(VirtAddr, size, order)
    if (b = m63..0) then
        StoreMemory(VirtAddr, size, order, m127..64)
    endif
    RegWrite(rb, 64, b)
MAS:
    b ← LoadMemory(VirtAddr, size, order)
    n ← (m127..64 & m63..0) | (b & ~m63..0)
    StoreMemory(VirtAddr, size, order, n)
    RegWrite(rb, 64, b)
MUX:

```



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```
b ← LoadMemory(VirtAddr,size,order)
n ← (m127..64 & m63..0) | (b & ~m63..0)
StoreMemory(VirtAddr,size,order,n)
endcase
enddef
```

#### Exceptions

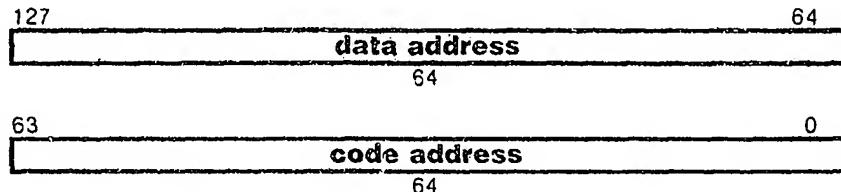
Reserved instruction  
Access disallowed by virtual address  
Access disallowed by tag  
Access disallowed by global TLB  
Access disallowed by local TLB  
Access detail required by tag  
Access detail required by local TLB  
Access detail required by global TLB  
Cache coherence intervention required by tag  
Cache coherence intervention required by local TLB  
Cache coherence intervention required by global TLB  
Local TLB miss  
Global TLB miss

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The gateway contains two data items within its structure, a code address and a data address:

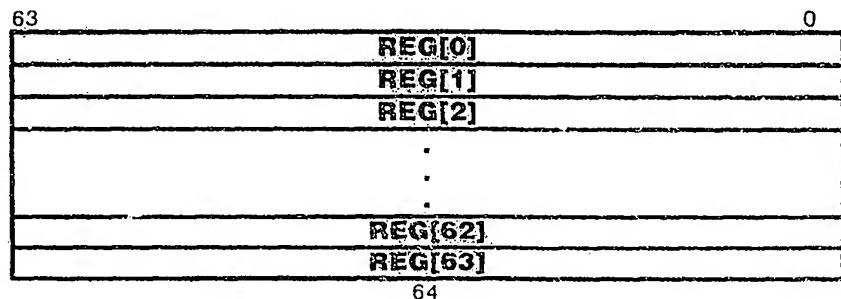


### User state

The user state consists of hardware data structures that are accessible to all conventional compiled code. The Terpsichore user state is designed to be as regular as possible, and consists only of the general registers, the program counter, and virtual memory. There are no specialized registers for condition codes, operating modes, rounding modes, integer multiply/divide, or floating-point values.

### General Registers

Terpsichore user state includes 64 general registers. All are identical; there is no dedicated zero-valued register, and there are no dedicated floating-point registers.



### Definition

```

def val ← RegRead(rn, size)
  case size of
    64:
      val ← REG[rn]
    128:
      if rn then
        raise ReservedInstruction
      endif
      val ← REG[rn+1] || REG[rn]
  endcase
enddef

```

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